

Kevin J. Miller
Exceptional Education Department
School of Education
Buffalo State College
Buffalo, NY 14222

Kevin Koury
California University – PA

Gail Fitzgerald
University of Missouri-Columbia - MO

Candice Hollingsead
Bethel College

Kate Mitchem
California University – PA

Hui-Hsien Tsai
University of Missouri-Columbia – MO

CONCEPT MAPPING AS A RESEARCH TOOL TO EVALUATE CONCEPTUAL CHANGE AND LEARNING GAINS

It is widely recognized that learning is a process unique to each individual. For each person, learning occurs when their personal knowledge is organized and re-organized into a conceptual structure (Jonassan, Howland, & Marra, 2003). Similarly, understanding, as it relates to new information, is constructed from conceptual reorganization of personal theories of the world, of which concepts are the cognitive components (Jonassen, 2006). This structure not only includes the content, but also its organization and inter-relatedness.

One process to evaluate conceptual change in learners is the method of semantic networking or concept mapping. Significant interest in the instructional use of concept mapping procedures has developed since their use was documented by Novak and Gowin in 1984. In a recent meta-analysis review of research studies that incorporated the use of concept maps, Nesbit and Adesope (2006) estimate that more than 500 peer-reviewed articles, most published since 1997, have made substantial reference to the educational application of concept mapping procedures.

Concept mapping has been used in a variety of education, psychology, and organizational settings (Croasdell, Freeman, & Urbaczewski, 2003; Stoddart, Abrams, Gasper, & Canaday, 2000). Although it's most prevalent use has been as a learning aid (Hill, 2004) or instructional tool (Stoddart, Abrams, Gasper, & Canaday, 2000), the potential use of

concepts maps as research tool for assessing student knowledge has been recognized (Van Zele, Lenaerts, & Wieme, 2004; Wallace & Mintzes, 1990).

Concept Maps

Concept maps (Novak & Gowin, 1984) provide a graphic representation of a person's structural knowledge or conceptual understanding of a particular topic. They can be used as a tool to visualize and measure the structure and organization of an individual's knowledge (Novak & Gowin, 1984; Ruiz-Primo & Shevaleson, 1996). The appearance of a concept map often looks like a spider web consisting of nodes that are connected by links to create diagrams that demonstrate conceptions of relationships among key ideas in a specific topic area (Croasdell, Freeman, & Urbaczewski, 2003). The nodes consist of words or ideas that represent information. The links between various nodes show how the concepts are conceptually and logically related within the concept map.

Concept maps are typically created through either a constrained or open-ended process. The constrained process requires the mapper to create their maps using a restricted list of terms supplied. The process may also restrict how the map may be drawn, and/or use a "fill-in-the-blank" approach. Contrarily, the open-ended process does not restrict how the map may be drawn and does not limit the mapper to a supplied list of terms, though a small number of prompt concepts may be provided.

Prominent Concept Map Scoring Approaches

Though numerous concept map scoring systems can be found in the literature, the scoring systems can be grouped into two general categories, quantitative or qualitative scoring methods. Quantitative scoring systems involve the counting of nodes or concepts, links, and levels according to a set of criteria and rules. Many quantitative scoring approaches are derivatives of a scoring system first proposed by Novak and Gowin (1984).

Qualitative scoring methods focus on assessing the content validity and accuracy of information presented in concept map. These methods may involve evaluating a concept map's content for how it is described and whether not desired terminology is included (Koury, 1994). Other qualitative scoring approaches include rating the quality of a concept map against an expert map (Lomask, Baron, Grieg & Harrison, 1992; Rye & Rubba, 2002) or interpreting the map based on analysis of the student map and subsequent interview (Van Zele, Lenaerts, & Wieme, 2004).

While the combination or mix of quantitative and qualitative analysis improves understanding of conceptual change in learners and helps to identify novice versus expert levels of conceptual structure, it fails to provide a qualitative measurement of change that can be used empirically. A system developed by Jones & Vesilind (1994) has been adapted and used by multiple researchers to measure conceptual change of learners (Alavi, Marakas, & Yoo, 2002; Jones, Rua, & Carter, 1998). An adaptation of this system was incorporated in the present study. Expert concept maps were developed to be used for assessing the correctness of content. Also created was a process for establishing inter-

rater reliability between experts and concept map raters prior to qualitative scoring of the maps.

An overview of the process used to numerically score and qualitatively rate over 500 concept maps constructed by higher education students enrolled in teacher education courses utilizing multimedia case-based instruction follows. The maps were collected and scored as a repeated measure of conceptual change related to case-based learning. The instruction occurred in multiple locations nationwide with pre-service and in-service teachers, in both special and general undergraduate/graduate education classes (Fitzgerald et al, 2004-2007).

The purpose of the research was to determine the extent of expansion of participant semantic structure using pre- and post-measures of pertinent special education language contained in participant generated open-ended concept maps. We were particularly interested in determining how the quality of the content of the concept maps changed over time.

The Concept Map Scoring Process

Collection of concept maps

Participants were provided training on how to create a concept map. After the training, each participant created pre- multimedia case-based instruction concept maps during their initial class sessions. Multimedia case-based instruction was provided in multiple contexts nationwide in over 18 college classes among four institutions of higher education. Participants created post-concept maps after the case-based instruction was provided. Pre- and post-concept maps were created on ledger size paper using a standardized 45-minute length of time.

Narrative comparisons of concept maps

Student comparison. After students completed the post-concept map, each was provided their pre-concept map. Students were instructed to review and compared their pre- and post-concept maps and write a reflective narrative response to the following two questions:

1. How has my concept of working with students who have emotional/behavioral disorders changed?
2. What has contributed to my changing views?

Researcher comparison. Researchers compared ten pre-post concept maps from each college class in which the multimedia case-based instruction was provided. Five pre-post concept maps were randomly selected from students in the interview group and five were randomly selected from the remaining students in the class. Researchers then wrote a narrative describing the organization, growth in learning, and correctness of information in the students' pre- and post-concept maps. They also described differences or changes noted between each student's pre- and post-concept maps.

Quantitative scoring of maps

The change in breadth, depth, and inter-connectedness of semantic structure was analyzed by counting the number of nodes, levels from center, and links on each concept map. A factorial analysis of variance was conducted to examine conceptual change for students on a pre-to-post comparison of concept map nodes and links across the four-course implementation. Statistically significant pre-to-post gains were found for number of nodes with interaction effects with course type with nodes; and pre-to-post gains were found for number of links with interaction effects with course type with links. Between-subjects analyses showed a mean increase on both nodes and links except for the undergraduate general education group.

Qualitative scoring of concept maps

Skeptical about using only a quantitative method to analyze the concept maps, a qualitative scoring scale to determine expansion of semantic structures and quality of content of pre- and post-concept maps was developed by the authors. The qualitative scoring scale was used to determine rating scores for student maps based on comparison of student maps to expert maps.

The process used to develop the qualitative scoring scale consisted of several steps. First, we created expert concept maps for each of the three multimedia programs used to provide the multi-media case-based instruction. This required identifying and reaching consensus on the “big ideas” and “relevant terms” students were expected to have gained from use of the program(s). These were umbrella words and all reasonable synonyms were acceptable. Next, the five level rating scale was created to rate the quality of concept maps against the expert maps. The comparison of the student maps to the expert maps was based on actual programs used by the student. For example, if the student used multimedia case Programs 2 and 3, we would compare the created concept map to both expert maps created for multimedia case Programs 2 and 3, but not Program 1.

A sample of student maps was selected and used to test the feasibility and reliability of the quality rating scale created. During this phase the authors selected a sample of student concept maps to score. We discussed the maps scored with the widest discrepancies and revised the qualitative scoring scale based on the discussion. A reliable qualitative scoring scale resulted with a clarification in decision rules and the anchors on the scale for rating the concept maps. The five levels of the final version of qualitative rating scale are:

- 0 none: represents no development of concept;
- 1 minimal/little: represents a novice/beginning level of development of concept;
- 2 fair/moderate: represents an emerging level of development of concept;
- 3 a lot: represents a great deal of development of concept between novice and expert;
- 4 expert: represents an expert level of development of concept.

Finally, a team of two raters was selected to score the remaining concept maps. Rater 1 and rater 2 were trained on how to score the concept maps using the qualitative scoring

scale developed by the authors. Inter-rater reliability was calculated between the two raters on three occasions. The overall inter-rater reliability score was 82%.

A factorial analysis of variance was conducted to examine the change in quality of the maps for students on a pre-to-post comparison of concept map quality scores across the four course implementation. All groups demonstrated growth as measured by the qualitative scores.

A comparison of the qualitative and quantitative results shows some interesting findings. First, quantitative analysis findings, for the most part, were consistent with qualitative analysis findings. Second, less can be more. One group's post-concept maps contained fewer nodes and links than their pre-concept maps. However, the comparison of the group's pre and post qualitative scores demonstrated growth in the validity of content and accuracy of information presented in concept maps. The next phase in our data analysis efforts will be to use the student and researcher written narrative reports comparing the pre- and post-concept maps to triangulate the qualitative data.

Final Thoughts

Though it took us several trials to develop a feasible and reliable scoring scale, we recommend the use of a qualitative method, such as the one developed and used in our study, to differentiate quality and assess content validity of concept maps. Valuable information came from comparing the pre- and post-concept maps using the qualitative scoring scale. The process and steps used to develop a qualitative scoring scale resulted in the construction of a reliable concept map scoring research tool. While we recommend the process, we caution that even though the instructions for holistic scoring may seem simple, the actual development of the scoring scale, as well as the scoring task, can be cognitively complex.

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